FOSSILIFEROUS CHERTS OF THE MIDWEST: THEIR ORIGIN, COMPOSITION, AND PREHISTORIC USE

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Introduction

Collectors and those involved in studying prehistoric Indian artifacts have almost certainly encountered remnants of fossils, both fragmentary and complete, preserved in the chert or flint of knives, blades, projectile points, scrapers and similar items. These fragments can resemble a variety of shapes, such as a circular or round mini-donut-like appearance, thin narrow linear fragments, a line of tiny dots, fragments having a cluster of tiny holes or pores, and others. The well known Harrodsburg chert from Kentucky is an outstanding example of a silicified "fossil hash" composed of broken fragments from a variety of former marine organisms. How did the Harrodsburg and similar fossiliferous cherts form and what kinds of fossil fragments are represented? Geologically, how old are these fossiliferous cherts and in what environment and what processes led to their formation? What kinds of fossil organisms comprise the bulk of these cherts and where and how did they live? What specific fossiliferous cherts were utilized by prehistoric cultures and how did they use them? Were fossils themselves used by prehistoric people for specific purposes? The aim of this paper is to answer these and related questions without getting bogged down in detailed geochemical information. Since the author is most familiar with the fossil record, geologic history and chert (and flint) varieties of Ohio, Indiana, and Kentucky, the focus of this paper will concern this region.

Origin and Formation of Chert and Flint

It is common knowledge that chert and flint are nearly identical types of sedimentary rocks which are composed of cryptocrystalline (or microcrystalline) quartz. All varieties of quartz have the chemical composition of SiO_2 or silicon dioxide and a hardness of 7 on the Mohs (Mineral) Hardness scale. Quartz varieties range from colorless rock crystal, to amethyst, smoky quartz, rose quartz, and milky (white) quartz, into the many microcrystalline varieties such as chert, flint, jasper, and agate. Minute impurities of various chemical compounds and other materials give quartz their tremendous array of colors. Mineral and rock collectors commonly seek out clusters of quartz crystals often associated with other minerals for showy display specimens, whereas lapidary enthusiasts collect, cut, tumble and polish the great variety of agates, and petrified wood for jewelry and related items. Due to the hardness of 7 and specific internal atomic structure of the silicon and oxygen atoms, all types of quartz will take on a high degree of polish when abrasive grits are utilized, as well as breaking with the distinctive conchoidal fracture. It is the conchoidal fracture and ability to control it which has enabled flint knappers, both ancient and modem, to fashion the great variety of points, blades, knives, and related items from chert, flint, jasper, and obsidian.

As mentioned, chert, flint, jasper and agate are all extremely, fine-grained siliceous rocks which are composed of cryptocrystalline quartz. Flint and chert are essentially the same rock, but the "rule of thumb" difference is that the term flint is commonly applied to those varieties which have a highly vitreous luster, fairly pure uniform composition, and are often somewhat translucent, whereas the term chert has been used for more impure varieties which have a dull or earthy luster and are often opaque. DeRegnaucourt and Georgiady (1998) do not differentiate and use the term chert for all varieties of chert and flint in their outstanding book, Prehistoric Chert Types of the Midwest. In a similar fashion, the term chert will be applied in this paper.

How does chert occur and how does it form? First, let me stress that the formation of chert involves some complex geochemical processes which are not totally understood. According to Tucker (2001) and others, chert can occur in variable sized nodules and thin lenses and layers often interbedded with limestone or as sequences of bedded chert, often comprising thick layered deposits associated with deep water, volcanic rocks which formed on the ocean floor. In either case, a source of silica (SiO_2) must be available in the sedimentary environment to provide the raw material which will geochemically precipitate and crystallize to form the cryptocrystalline chert. The formation of chert can probably follow several different geochemical pathways. Some sedimentologists believe that the silica can take on the form of a colloidal gel which eventually crystallizes into the chert. An important consideration related to the silica is where does it come from? Tucker (2001) believes the source of the silica can be both biogenic, i.e. derived from organisms which possess siliceous (SiO_2) skeletal components, as well as inorganic (nonbiogenic) whereby the silica is as a chemical precipitate from submarine volcanic activity or hydrothermal (high temperature chemical fluid) activity on the deep ocean floor. Geologically, the bedded cherts are closely associated with deep sea volcanic rocks, such as submarine basaltic lava flows and related oceanic sediments. An outstanding environment where this sequence of rocks can form would be along the active midocean ridges of the world's ocean basins (eg. Mid-Atlantic Ridge or East Pacific Rise). There in the rift valleys new oceanic crustal rocks such as pillow lavas of basaltic composition are forming from submarine volcanism. This is also the location of high temperature hydrothermal vents called "black smokers" which spew out chemical fluids from fractures in the oceanic (basaltic) crust. At the same time, thousands of feet above in the surface waters of the open ocean are vast numbers of tiny microorganisms called plankton which form the base of the oceanic food chain. Diatoms, the main phytoplankton, as well as radiolarians, which are zooplankton, both have siliceous microscopic skeletons which slowly settle to the deep ocean floor. As layers of these siliceous skeletons accumulate and are buried by sequences of submarine lava flows and oceanic sediments, they provide the biogenic silica which can eventually crystallize into the bedded cherts. Ghosts of radiolaria can sometimes be seen preserved in the chert. According to Tucker (2001), the hydrothermal chemical fluids can also provide the inorganic source of dissolved silica, as well as some being derived from the devitrification of volcanic ash layers. In summary, oceanic bedded cherts appear to be formed from both biogenic (organic) and inorganic silica sources.

Nodular masses, lenses and irregular layers of chert also commonly occur within or in association with carbonate rocks, such as limestone and dolomite (dolostone). Limestone and dolomite are commonly referred to as carbonate rocks by geologists because their chemical composition is calcium carbonate ($CaCO_3$) and calcium magnesium carbonate ($CaMgCO_3$), respectively. According to Tucker (2001), nodular and layered cherts within limestones have a replacement origin. This involves biogenic siliceous sediment, deposited within the overall calcareous sediment, dissolving and forming a silica gel which replaces some of the $CaCO_3$, skeletal material in the deposit and crystallizes into the microcrystalline chert. Again, a complex geochemical process over time.

Most limestones (carbonates) begin their formation in shallow, warm marine waters, usually in tropical or subtropical settings. The shallow waters of the Bahamas, Florida

Keys, Florida Bay, and the Persian Gulf are all examples of modem carbonate areas. In these regions, the warm shallow waters are nearly supersaturated with calcium carbonate, thus it is quite easy for calcium carbonate to precipitate out and form fine carbonate mud particles. In shallow sand bar areas, where tidal currents move back and forth daily, tiny round grains of $CaCO_3$ called ooids or oolites can chemically precipitate out of the water and form what are called oolite shoals. In addition, the great majority of marine organisms, such as clams, snails, corals, and echinoderms, living in these shallow waters possess calcareous shells or skeletal components. Upon death, these skeletal materials become part of the bottom sediment deposit. However, a source of silica (SiO_2) is still needed within the calcareous sediment to form the chert. Where does the silica come from? Carlson (1994) and Tucker (2001) both believe that siliceous sponge spicules accumulating in large amounts within the carbonate sediment provide the bulk of the biogenic silica for the formation of the chert. Sponges are marine organisms which contain within their body tissue microscopic skeletal elements called spicules, composed of either $CaCO_3$ or SiO_2. After the death of a sponge, the spicules become tiny biofragments within the sediment. According to Carlson (1994), important Pennsylvanian cherts (flints) of Ohio, such as the Upper Mercer, Vanport and Brush Creek, originated in a shallow marine deposit along a swampy shoreline where extensive colonies of siliceous sponges lived and died and provided huge amounts of opaline silica spicules. These spicules provided the primary silica which crystallized to form the flint layers within the limestone, as well as replacing the calcareous skeletal materials in the flint beds. In addition to the siliceous spicules, diatoms could also be a source of silica, if present.

Geological Ages of Midwestern Cherts

How old are the chert (flint) deposits which occur in Ohio, Indiana and Kentucky? First, one needs to consider the age of the bedrock in this portion of the Midwest. If you remove the glacial deposits which overlie the bedrock in the glaciated areas of this region, one would find Paleozoic age sedimentary bedrock exposed at the surface throughout the entire area. How old are Paleozoic age rocks? The Paleozoic Era began about 544 million years ago and ended about 245 million years ago (Figure 1). Consulting the Geologic Time Scale (Figure 1), the surface bedrock of Ohio ranges from Ordovician age upward through the Paleozoic to Permian age units. The varieties of these layered sedimentary rocks include sandstones, shales, conglomerates, coal beds, and carbonate rocks, such as limestones and dolomites. As mentioned, the nodular and layered chert (flint) deposits mainly occur within the limestone and dolomite units. Below the Paleozoic bedrock of Ohio and the Midwest lie rocks of Precambrian age which can range from about 550 million years of age back to nearly 3.8 billion years old.

In their book on Midwestern chert types, DeRegnaucourt and Georgiady (1998) discuss and illustrate about 51 different cherts (including chert varieties) from the states of Ohio, Indiana, Kentucky, Illinois, Michigan, Tennessee, New York and the province of Ontario. The geologic ages of these cherts are entirely Paleozoic ranging from the oldest being Ordovician to the youngest being Pennsylvanian in age (Figure 1). Nearly all of these cherts occur within or in association with limestone or dolomite and most contain fossils. In many of these cherts, the fossils are not noticeable partly because they are microscopic in size (such as sponge spicules and some microfossils) and need to be viewed in thin-section or under magnification. Also, the fossils may be sparse and quite scattered in some cherts. However, the types of fossils present and their occurrence in these shallow shelf, marine limestones indicates that these cherts were formed by the replacement of calcium carbonate skeletal material and lime matrix by silica which crystallized into the fossililferous chert nodules, lenses and layers we see today. The vast majority of marine organisms including clams, snails, bryozoans, echinoderms, and corals possess $CaCO_3$ skeletal components and shells which are later replaced by silica to form the chert. Because limestones and carbonate sediments are quite soluble, the replacement of $CaCO_3$ by silica is possible.

What are the specific geologic ages of the important prehistoric cherts in the Midwest? Data from DeRegnaucourt and Georgiady (1998) indicates that of the 18 Ohio cherts (including varieties), 4 are Silurian, 3 are Devonian and the majority (11) are Pennsylvanian in age. The main reason that eleven Pennsylvanian age cherts occur in Ohio is that the Vanport flint, better known to collectors as the famous Flint Ridge flint and its varieties (Chalcedony, Nethers, Moss agate) and the Upper Mercer chert and its varieties (Coshocton Black, Gray, Nellie, and Bird-Dropping) are geologically Pennsylvanian in age (Figure 1). Also, importantly, a large amount of the bedrock in east central and eastern Ohio is Pennsylvanian in age. In Indiana, the eleven predominant chert types are of the following geologic ages: Silurian (3), Devonian (1), Mississippian (6), and Pennsylvanian (1). The following well known Indiana cherts: Attica (Indiana Green), Harrison County (Indiana Hornstone) and Harrodsburg are all Mississippian in age. In Kentucky, the eight predominant cherts are of the following geologic ages: Ordovician (1), Devonian (1), Mississippian (5), and Pennsylvanian (1). The Paoli (Carter Cave), Sonora, Haney, and Muldraugh/Ft. Payne cherts from Kentucky are all Mississippian in age. In Illinois, five of the six cherts surveyed, including the well known Burlington, Mill Creek, and Cobden/Dongala cherts are also of Mississippian age. Why are Mississippian age cherts so prevalent? Mainly because Mississippian limestones are quite widespread throughout the states of Kentucky, Indiana, and portions of Illinois, Tennessee and Missouri and it is within many of these limestones that abundant chert nodules and lenses occur.

Why are shallow marine limestones of Paleozoic age so prevalent in these Midwestern states? During much of Paleozoic time, beginning with the Ordovician and continuing through the Pennsylvanian, much of what is now eastern North America and the Midwest was covered by shallow, continental seas. These were not deep oceanic waters, like the modem Atlantic and Pacific Ocean basins, but rather shallow shelf seas which ranged from shoreline depths to several hundred feet deep. In areas where there was not an ongoing influx of sands, muds and clays from rivers and streams, such as in offshore regions, carbonate sediments could form and accumulate as the dominant seafloor deposits. After gradual burial, compaction, and lithification over millions of years, the eventual results are the limestone formations we see exposed as surface bedrock today.

Taking a brief look at this portion of Ohio's geologic history, the extremely fossiliferous limestones and shales of the Cincinnatian Series (Late Ordovician) which underlie greater Cincinnati, southwestern Ohio, and northern Kentucky today formed in these shallow seas. During the Silurian period, shallow marine conditions existed from Ohio to Indiana, Illinois and Wisconsin forming an extensive carbonate shelf environment in which reefs flourished. During the Devonian period, Ohio became a semi-restricted marine environment, yet some limestones (eg. Delaware and Columbus Lms.) were deposited, later to be covered by the Ohio Shale. During Mississippian time, Ohio was the location of several large delta complexes which prograded into the state from the north, east and southeast depositing the Bedford Shale, Berea Sandstone, and Black Hand Sandstone of the Cuyahoga Formation. Some of these thick deltaic sandstones (eg. Black Hand) can be seen today as the cliffs and caves in the Hocking Hills area (eg. Old Man's Cave and Ash Cave). These large deltas formed due to tectonic activity causing the rise of the Appalachian Mountains in the east which provided the sediments that were carried westward into western Pennsylvania, eastern Ohio and eastern Kentucky. As this was happening, shallow warm seas continued to exist in Indiana, central and western Kentucky, Illinois, Missouri and further west where extensive thick limestones of Mississippian age were forming. The Mammoth Cave system, as well as the many other caves of Kentucky, Tennessee and Missouri are developed in these Mississippian limestones. In addition, the famous "Indiana Limestone" of southern Indiana, probably America's most famous building stone, was deposited at that time.

Finally, during Pennsylvanian time, Ohio became a transitional area of coastal deltas and low lying swamps and marshes, whereas shallow marine conditions continued to the west in Indiana and beyond. Thick deposits of coastal swamp vegetation and organic material were deposited and periodically buried as the deltas, river channels and shorelines shifted and changed position over time. These buried swamp deposits eventually formed into the Pennsylvanian coal beds of eastern Ohio, western Pennsylvania, West Virginia and eastern Kentucky we see today. However, periodically, thin marine limestones (eg. Vanport, Upper Mercer, and Brush Creek Lms.) were deposited and it is within these shallow marine limestones that the famous flint and chert beds (eg. Flint Ridge and Upper Mercer chert) were formed.

Fossil Composition of the Chert

How do we know that these fossiliferous cherts were formed by the replacement of some of these marine limestones by silica? By far, the best evidence is the presence of both complete and fragmentary marine fossils within the chert. As mentioned earlier, the vast majority of marine invertebrates have shells or skeletons composed of $CaCO_3$ which can be in the form of the minerals calcite or aragonite. The presence of these fossils composed of SiO_2 either in chert or limestones proves that replacement has occurred. What types of fossils are most commonly found preserved in these Paleozoic cherts? The organisms which mainly comprise Paleozoic marine bottom communities are brachiopods, bryozoans, crinoids, corals (both solitary and colonial), snails, clams, nautiloids, trilobites, and stromatoporoids. Of these, the crinoids and brachiopods leave behind the most abundant, recognizable biofragments.

Crinoids

Sometimes called "sea lilies" crinoids belong to the phylum Echinodermata which means "spiny-skinned animals." This same phylum includes starfish, brittle stars, sea urchins (echinoids), sand dollars, and a number of extinct groups known only in the fossil record, such as cystoids, blastoids, eocrinoids, carpoids, edrioasteroids, and others. Most crinoids of the Paleozoic were stalked crinoids; that is they had a flexible stalk or stem composed of many small, button shaped calcite plates called columnals, held together by muscles and epidermal tissue (Figure 2). At the top of the stalk was the calyx, an enlarged region made of calcareous plates which housed the vital soft parts and from which a variable number of flexible feeding arms arose. All along the arms were many small pinnules which functioned to help snag food particles from the water and pass these to food grooves on each arm which in turn carried the particles to the mouth located on the upper surface of the calyx. The arms, pinnules and small side branches along the stalk called cirri were also composed of tiny calcareous plates. Located at the lower end of the stalk was usually a branching root-like structure called the radix, which served as a hold-fast to root or attach the crinoid to the sea floor. Some crinoids lacked a radix and simply coiled their tapered stem around an available object on the seafloor. Others had odd-ball types of anchoring features. Crinoids are suspension feeders and use their arms, pinnules and tiny tube feet to trap food particles. Many spread their arms outward to form a circular filtration fan, such that microorganisms and other tiny food particles being carried by bottom currents flowed through the fan and became trapped.

According to Ausich and Lane (1978) nearly 6000 fossil crinoid species are known. The earliest crinoids appear in the Ordovician period and they become more abundant and diverse through the Paleozoic. During the Mississippian period, crinoids reach their peak in diversity, overall abundance and size; thus the Mississippian is sometimes referred to as the "age of crinoids." During the Triassic period, a new group of stalk-less, free-swimming crinoids called the comatulids appear. In modem seas, both types exist with many of the comatulid crinoids adapted for life in shallow water reef areas, whereas the stalked crinoids have declined in number and migrated to deeper waters.

When crinoids die, their soft tissue and muscles decompose and they generally disarticulate ("fall apart") into the many different calcareous plates and columnals of which they are made. Crinoids which are buried quickly by bottom sediments before disarticulation have been preserved as complete, often quite spectacular fossils. Ausich (1996) reports that nearly every complete fossil crinoid was probably buried alive by a sudden rapid burial event, perhaps caused by a storm. However, the vast majority of crinoids fall apart and their columnals and plates become biofragments on the seafloor. Most Paleozoic crinoid species lived in shallow shelf areas, often in quite shallow water on and around reefs where bottom currents and water turbulence enhanced the disarticulation process. Obviously, water turbulence and agitation of calcareous biofragments on the seafloor, be it high energy conditions such as during a storm or moderate to lower energy over time has the net effect of breaking shells and skeletal materials into smaller sized fragments. The Brassfield Limestone of early Silurian age in southwestern Ohio contains layers almost entirely composed of disarticulated crinoids and represents a former crinoidal hash (Figure 3). Within the Late Ordovician Cincinnatian Series thin crinoidal-limestone layers occur which are composed of thousands of small crinoid columnals (Figure 4). During the Mississippian period, the sheer abundance of crinoids populating the seafloor contributed vast amounts of columnals and plates which later lithified into the famous Mississippian crinoidal limestones, such as the Burlington Limestone (Figure 5) and others (Levin, 1978). Replacement of these crinoidal limestones by silica results in cherts which often contain quite recognizable crinoid columnals and plates.

Brachiopods

This group of bivalved marine organisms is one of the most abundant in Paleozoic seafloor communities with over 30,000 fossil species having been described (Levin, 1999). Belonging to the phylum Brachiopoda, these organisms possess two calcareous shells which hinge along one margin and are opened and closed by coordination of sets of muscles (Figure 6). They have a coiled, ciliated internal organ called the lophophore with which they set up water currents and sweep food particles into the shell interior to the mouth. Brachiopods first appear in the Cambrian period and increase in abundance and diversity until reaching their peak diversity during Devonian time, after which they begin to decline. Several groups continue on through the Mesozoic and still exist today in modern seas. Brachiopods were the dominant bivalved shellfish of the Paleozoic seas; however, during the Mesozoic and Cenozoic eras, bivalve mollusks (clams and oysters) and gastropods (snails) become the dominant shellfish, When brachiopods die, the soft parts either decompose or are eaten by a predator or scavenger and the two shells often separate. This is also true for bivalve molluscs. Just like crinoid debris, these shells accumulate on the seafloor (Figure 7) and over time wave energy and bottom turbulence break them down into shell fragments. This is especially true of the thin-shelled species. In this way, brachiopod and molluscan shell material become calcareous biofragments and major components of marine limestones (Figure 7). Broken brachiopod shell fragments in chert usually appear as thin, linear plate-like fragments when viewed in cross-section.

Bryozoans

These colonial marine organisms are sessile (attached), bottom dwelling animals which exhibit growth forms ranging from small twig-like (branching), to globular, to encrusting, to delicate fan-like colonies. Although about 4000 living species are known, at least 16,000 extinct species have been described as fossils (Levin, 1999). The living bryozoan colony consists of dozens to hundreds of tiny individuals called zooids, each a filter feeder with its own minute lophophore. Most fossil bryozoans secreted a calcareous skeletal structure, which like the preceding groups can be broken down into variable-sized biofragments.

Molluscs

This huge group, belonging to the phylum Mollusca, consists of bivalves (clams, oysters, mussels), gastropods (snails), cephalopods (squids, octopods, and fossil shelled forms such as nautiloids and ammonoids), and several minor groups. The modern Chambered Nautilus is the last surviving nautiloid. As mentioned, most molluscs have calcareous shells which undergo the same breakdown processes and become biofragments.

Corals

During the Paleozoic, two basic types of corals appear and become viable members of marine benthic (bottom) communities. Horn corals represent solitary coral polyps which had the ability to secrete a calcareous horn-shaped skeleton. One end is pointed, whereas the opposite rounded, open end forms a cup-like depression in which the coral polyp was located. Modern sea anemones, which lack a skeleton, resemble the polyp of a horn coral, complete with numerous fleshy tentacles armed with nematocysts (stinging cells) which surround its mouth. As carnivores, anemones and corals utilize their nematocysts to paralyze prey organisms on which to feed. Fossil horn corals can range from about 1 to 6 inches in length and after death became skeletal material on the seafloor. Because the skeleton was fairly strong, many remain intact and did not break apart easily into fragments. Colonial corals represent the other major type and consist of hundreds to thousands of tiny polyps which inhabit small chambers (corallites) on the colony surface. The calcareous skeleton may be hemispherical to branching to plate-like and after death can remain somewhat intact or break apart into fragments. One of the most well known fossil colonial corals is the genus Hexagonaria which lived in Devonian seas, especially those which once covered Michigan, and fragments of which are now known as Petoskey stones. Horn corals lived only during Paleozoic time, whereas colonial corals range from the Paleozoic to the recent and today numerous species represent important framework builders of modern coral reefs.

Miscellaneous groups

Sponges of various types have populated marine benthic communities since the early Paleozoic. Their main skeletal elements are microscopic sized spicules of a variety of shapes and composed of either SiO_2 or $CaCO_3$. As sponges die and their cells and soft parts decompose, the tiny spicules become liberated as biofragments in the bottom sediment. As mentioned previously, siliceous spicules provided a source of silica which is believed to be the raw material of numerous Paleozoic cherts. In addition, tiny sponge spicules can still be recognized as fossils in some Midwestern cherts, such as the Bisher, Brassfield, Upper Mercer, and others (DeRegnaucourt and Georgiady, 1998). Other microfossils seen in some cherts include single-celled protozoans called foraminifera, such as the distinctive fusulinids of Pennsylvanian and Permian age. Plates and columnals from other groups of attached Paleozoic echinoderms, such as cystoids and blastoids, also contributed calcareous biofragments and could be preserved in fossiliferous cherts. However, these groups are minor when compared to the preponderance of biofragments and skeletal hash contributed by crinoids, brachiopods, and bryozoans.

Prehistoric Use of Fossiliferous Cherts

The initial focus of this paper was on Midwestern cherts which were visibly fossiliferous, such as the distinctive Harrodsburg chert (Figures 8 and 9) which represents a former calcareous skeletal hash of Mississippian age which was replaced by silica. Other cherts which are either somewhat similar or commonly contain visible fossil fragments include the Bisher, Brassfield, Upper Mercer, Burlington, Boyle, Muldraugh Ft. Payne, and Pipe Creek. The Muldraugh Ft. Payne chert often shows a distinctive mottled appearance due largely to the presence of filled fossil burrows. After doing a survey of the 51 different cherts described by DeRegnaucourt and Georgiady (1998), I was surprised to learn that 94% (48 of the 51 cherts) contain fossils. One could conclude that the majority of cherts are somewhat fossiliferous; however, most are either only sparsely fossiliferous or the fossils are microscopic in size and generally not visible except under magnification or in thin-section. In addition, fossil material in the chert has sometimes undergone recrystallization which makes identification of the fragments difficult.

It is evident to anyone interested in prehistoric artifacts that chert (flint) of nearly any variety, when available, was probably the most commonly used material to knap projectile points, spear heads, knives, blades, drills, scrapers, and other similar tools. The ability of prehistoric flint knappers to take advantage and control the conchoidal fracture of chert and similar materials like obsidian (volcanic glass) has enabled the manufacture of many varieties of high quality, points, blades and other chert artifacts. Fossil fragments or fossil inclusions within the chert sometimes created problems for ancient flint knappers. High quality, homogenous, rather pure cherts such as the Flint Ridge varieties and Harrison County chert (Indiana Hornstone) were highly sought and used, in part, because they did not contain a lot of problematic imperfections and inclusions. However, the fossiliferous cherts mentioned earlier, were certainly utilized as both viable and colorful cherts by prehistoric cultures.

DeRegnaucourt and Georgiady (1998) have compiled a tremendous amount of information concerning the recognition, characteristics, composition, source areas, geographical distribution, and prehistoric use by cultures through time of the common Midwestern and related cherts. I heartily recommend their work to anyone interested in detailed information about this subject. Since the focus of this paper is on visibly fossiliferous cherts, some of their data on prehistoric use is relevant here. The Upper Mercer chert, especially the blue-black variety often shows visible fossils and according to DeRegnaucourt and Georgiady (1998) probably no other Ohio chert was as widely used in all prehistoric time periods. Color photographs of Upper Mercer (Coshocton) black chert in their book, as well as Converse (1994) show visible fossil fragments and inclusions. The Harrodsburg chert of southern Indiana is very distinctive in its appearance mainly because it consists of a mixture of very visible, broken fossil fragments (Figures 8 and 9). It represents the classic example of a former fossil hash which has been replaced by silica (silicified). The Harrodsburg chert was utilized somewhat during the Early and Middle Archaic, but reached its peak use during the Late Archaic when prehistoric people used it to manufacture Brewerton, Schershel and Raisch-Smith points (DeRegnaucourt and Georgiady, 1998).

The Brassfield and Bisher cherts are both from southern Ohio and are sometimes visibly fossiliferous, often showing the characteristics of a finely textured, fossil hash. The Brassfield was used through all prehistoric periods with frequent use by the Ft. Ancient people to manufacture their triangular points and knives, whereas the Bisher chert saw peak usage in the Late Archaic and was also utilized by the Adena culture during Early Woodland time (DeRegnaucourt and Georgiady, 1998). Color photographs of the Bisher chert in Converse (1994) illustrate several examples showing a finely textured, fossil hash. The Cedarville-Guelph and Pipe Creek cherts often contain either visible fossils or fossil inclusions. The Cedarville-Guelph of west central Ohio was primarily utilized by Late Archaic and Middle Woodland cultures, whereas the Pipe Creek of northern Ohio was used throughout the Archaic and by the Adena (Early Woodland) people (DeRegnaucourt and Georgiady, 1998).

Prehistoric Use of Crinoid Columnals

As mentioned earlier, the flexible stalk or stem of an attached crinoid is composed of numerous, generally round, disc-shaped skeletal elements called columnals. These range in size from about 1/4 to 1 inch in diameter depending on the overall size of the crinoid species. Obviously, smaller species with stems of less than a foot in height had much smaller diameter columnals than larger species which ranged from 2 to 3 feet or more in height. Each calcareous columnal has a central opening (or hole) through which the living tissue extended through the stem during life. When crinoids die, their button-like columnals composed of calcite generally disarticulate and become scattered in the seafloor sediment. Geologically, hundreds of thousands of these columnals, along with other fossils (brachiopods, bryozoans and others) become buried in the sediment, compacted, and cemented into ancient Paleozoic limestones (Figures 3, 4,5). Depending on the geologic history of these buried limestones, many of the fossils can remain calcareous and well preserved, others may undergo recrystallization, and others may be replaced by silica. Millions of years later, as these limestone formations become exposed by erosion at the earth's surface, many of these columnals and other fossils begin to weather out of the limestone. Usually, the limestone matrix (i.e. the background, fine grained calcareous sediment that encloses the fossils) chemically weathers and dissolves away more quickly than the fossils, which then often accumulate and can be picked up on the ground. Thus, these weathered out fossils could easily be collected by prehistoric Indians, as well as modem fossil collectors.

There is evidence to show that some prehistoric Indian cultures made use of fossil crinoid columnals as beads. The fact that most columnals resemble beads is probably the main reason they were used as such. The majority being rounded, flat, button-like and with a central opening made them a "naturally formed" bead. Rather than spending time making button-like beads from molluscan shells, some prehistoric people could use crinoid columnals in areas where they were available and easily collected. A site in Montgomery County. Ohio has yielded a large number of columnals presumably used as beads. About 173 of these columnal beads have been strung to illustrate how they could have functioned as an ornamental necklace (Figure 10). These columnals are quite distinctive and probably weathered out of the Early Silurian Brassfield Limestone which outcrops in southwestern Ohio. I have personally collected fossil columnals of this type from weathered Brassfield limestone exposures near Fairborn. Greene County. Ohio. This necklace was donated to and is in the collections of the Clark County Historical Society.

Another similar use of crinoid columnals as beads is illustrated by Hothem (2003. p. 276). This necklace appears to consist of about 170 columnal beads and was found in Christian County, Kentucky. The necklace is illustrated along with 6 disc-shaped shell beads, as well as a bear canine tooth and a drilled raccoon penis bone. All these items are reported to have come from Christian County, but it is not known if all were found in association. Hothem (2003) interpreted the items to be probably Archaic in age. In summary, I am fairly certain that crinoid beads have been found at other archaeological sites, especially in areas rich in crinoidal limestones, such as Kentucky, Indiana, Tennessee, and Missouri. Their use may range from the Archaic through the Ft. Ancient cultures.

Conclusion

One of the main purposes in writing this paper was to highlight some of the common Midwestern cherts which are visibly fossiliferous and to discuss their origin and formation. Another goal was to present the most common types of fossils one might encounter in these cherts and briefly discuss their morphology, habitat and mode of life. A related objective was to focus on how these cherts fit into the regional geologic history of the Midwest, specifically Ohio, Indiana, and Kentucky, and which ones were actively used by which prehistoric cultures. It is hoped that the reader has gained some new information and knowledge relative to fossiliferous cherts and their origin and content.

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The author made considerable use of the information presented in *Prehistoric Chert Types of the Midwest* by Tony DeRegnaucourt and Jeff Georgiady and commends them on this outstanding contribution to the field of Midwestern archaeology and lithic studies. I also thank Virginia L. Weygandt, Curator of Collections at the Clark County Historical Society, for permission to study the crinoid bead necklace in the CCHS collections.

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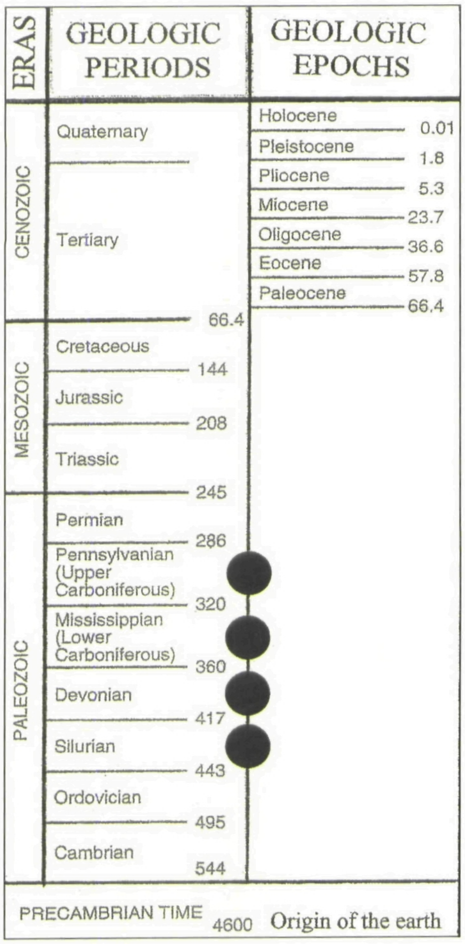

Figure 1 (Morris). The Geologic Time Scale. The numbers represent dates in millions of years before the present. The dots represent the geologic ages of common Midwestern cherts. Modified from Brice, Levin and Smith, 1997.

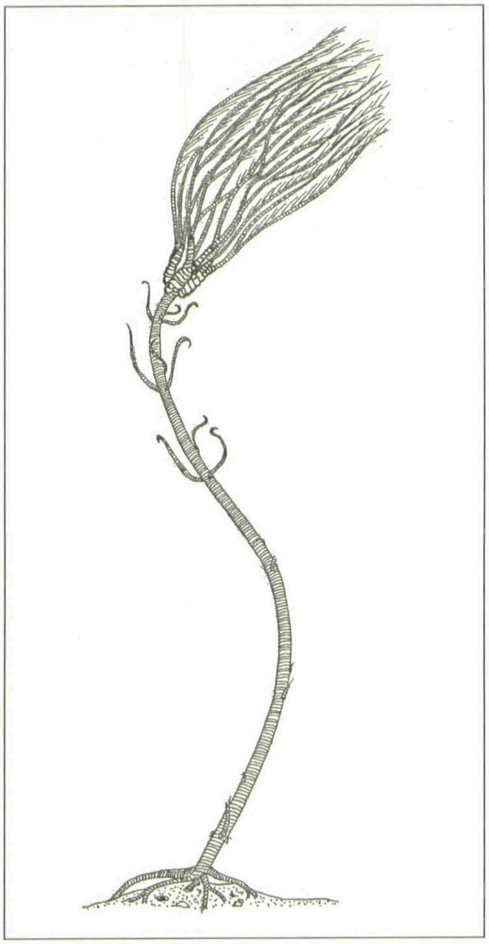

Figure 2 (Morris). A generalized crinoid attached to the seafloor showing the major body plan. Modified from Levin, 1978.

Figure 3 (Morris). The weathered surface of a crinoidal-limestone; the Brassfield Limestone, Early Silurian age, from near Fairborn, Ohio. Note the numerous, round crinoid columnals and articulated stem fragments.

Figure 4 (Morris). The weathered surface of a Late Ordovician age limestone layer consisting almost entirely of small crinoid columnals. Fairview Fm., Mason County, Kentucky.

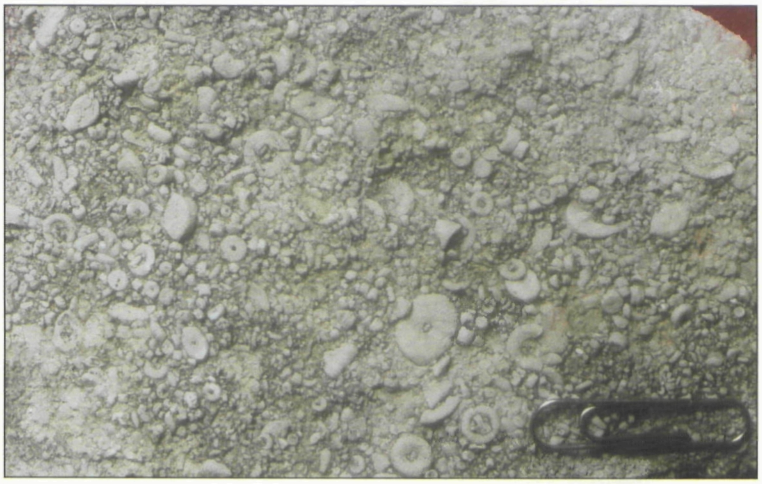

Figure 5 (Morris). The weathered surface of the famous Burlington Limestone, a classic Mississippian age crinoidal limestone from near Springfield, Missouri. Nearly all the visible fragments are crinoid remains.

Figure 7 (Morris). Disarticulated shells of the brachiopod Onniella, exposed on the surface of a Late Ordovician limestone layer; Waynesville Fm., from near the Brookville Reservoir, Indiana.

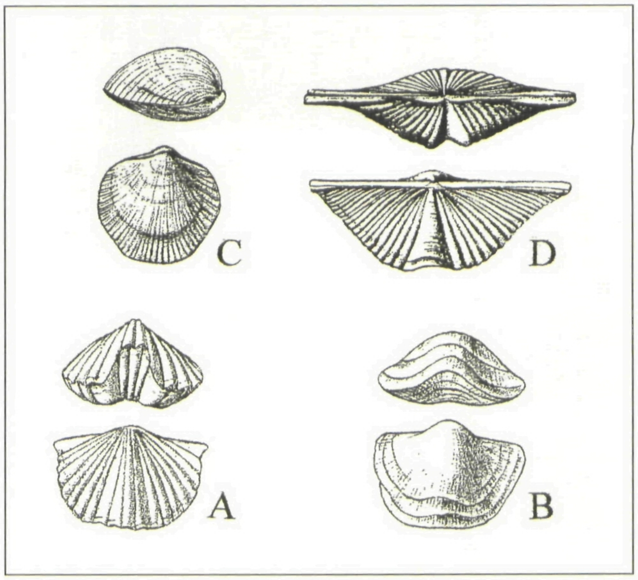

Figure 6 (Morris). Sketches of some common Paleozoic brachiopods; A = Platystrophia, B = Hebertella, both Ordovician in age. C = Atrypa, D = Mucrospirifer, both Devonian in age. Adapted from Collinson, 1959.

Figure 8 (Morris). Three artifacts made of Harrodsburg chert from Indiana. The knife on the left measures 3 3/4 inches in length.

Figure 9 (Morris). An oval knife/scraper or preform made of Harrodsburg chert, nearly 4 inches in length. Note the small round crinoid columnals and abundant fossil fragments throughout.

Figure 10 (Morris). Crinoid columnal bead necklace from Montgomery County, Ohio. All of the columnals are from the Early Silurian age Brassfield Limestone and many are the "cog-wheel" variety noted by Ausich (1996).